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Landsat 4 Scientific Characterization

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Information Content of Data from the Landsat-4 Thematic Mapper (TM) and Multispectral Scanner (MSS)

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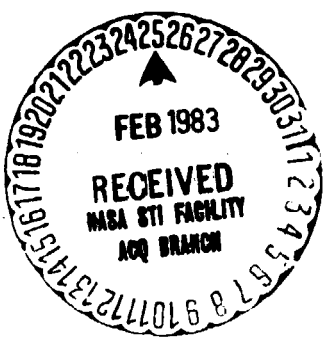

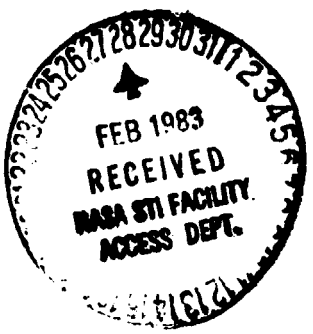

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INFORMATION CONTENT OF DATA FROM THE LANDSAT 4 THEMATIC MAPPER AND MULTISPECTRAL SCANNER

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The object of the investigation is to quantify the increased information content of Thematic Mapper (TM) data as compared to that from the Landsat 4 Multispectral Scanner (MSS). Here the word 'information' is used in the technical sense, representing the statistical variability within a data set.

An intuitive concept of the information content of image data may be gained from several examples: 1) A uniform featureless scene, such as a desert area, has a low information content while a "busy" scene, such as a city, contains more information; 2) A scene having no spectral variability, i.e. all wavelength channels having a common brightness value at each point - a black and white scene, has a lower information content than one in which brightness values differ from one spectral channel to another in a spatially varying way - a multicolored scene; 3) A data set obtained at low spatial resolution has many features blurred or averaged out, and thus has a lower information content than the equivalent scene observed at higher resolution.

In the present case, the TM data contain more information than the MSS data because of 1) the greater number of spectral channels, 7 versus 4, 2) the improved spatial resolution, 30m versus 82m, and 3) the increased precision resulting from better detector response and decreased quantization intervals, e.g., 8 bit versus 6 bit data.

Successful completion of this work will provide NASA with a sensitivity estimate as to the degradation of information resulting from errors and/or simplifications in processing of Thematic Mapper data. In addition, it will provide NASA with technical information relative to engineering tradeoffs and specifications for the development of more advanced instrumentation.

For the USDA, the study will provide a basis for evaluation of the impact of upgrading MSS oriented hardware and software to process TM data vis-a-vis the increased information content of the data.

The analysis procedure consists of the application of standard mathematical methods (principal components, supervised classification, autocorrelation, etc.) to data sets from the MSS and TM. The subject area, information theory, is well developed and software already has been developed for most tasks.

Accomplishments

(1) Construction of software to reformat data to band interleved format.

(2) Development of analysis software.

(3) A number of computer runs have been carried out for several subareas from a data set acquired simultaneously by TM and MSS over a test area in northeast Arkansas. (Scene center North 36°02', West 90°02', date, August 22, 1982) This scene is one of the most agriculturally diverse areas in the U.S. As one would expect, the 6 visible-near IR channels of the thematic mapper provide more information than the 4 channels of the multispectral scanner. A rough estimate of 20 bits per pixel for TM, 10 bits per pixel for MSS has been computed for these subareas. These numbers will be revised downward when allowance is made for noise in the data.

Since the 6 reflective channels of the TM have a capacity of 48 bits per pixel (6 channels x 8 bits per channel) while the 4 MSS channels have a capacity of 27 bits per pixel (3 x 7 bits + 1 x 6 bits) one can readily compare the information gathering efficiency of the two instruments. It appears that the ratios (information per pixel)/(possible information per pixel) are approximately equivalent - $20/48 \approx 10/27$, with noise not yet accounted for. If data utility is related to the quantitative estimate of information then the greater spatial and spectral capability of the TM represents a substantial improvement in remote sensing technology. However, the present assessment is preliminary and study of additional data sets is required.

Problems and Recommendations

(1) This proposal included a request for use of the Landsat assessment system (LAS) for viewing of image data. This requirement is based on the need to make comparisons for identical geographic areas for the TM and MSS, and to facilitate discrimination of recognizable features from salt and pepper (noise) in the image data.

Several efforts were made to utilize the LAS facility, but the state of system integration and documentation is inadequate for scientific studies and will remain so for some time. The LAS requirement will be met by a desk top image processor in my office: The principal task remaining is to ingest data over a phone line from the large USDA Computer in Washington. The desk top unit does not have a tape drive.

(2) No night thermal IR data have been received to date. Otherwise, data availability is not a problem: Matched TM and MSS has been received for Northeast Arkansas and for Washington, DC. A third pair will be selected from the many available.

(3) Project documentation is extremely voluminous but tends toward engineering details and tables. It would be helpful to have a NASA scientist condense documentation to the significant details.

Publications and Presentations

(1) Presentation of this material at the Goddard Space Flight Center Meeting January 11, 1983.

Data Received as of 2-11-83:

1)	"Lamp" Data	(8-3-82)		(returned)
2)	Detroit Area - 4 bands Appears to have processing errors or noise	(9-8-82)	TM-P	(returned)
3)	North East Arkansas Band 6 bad (?)	(9-8-82)	TM-P	
4)	North East Arkansas	(11-1-82)	TM-A	
5)	North East Arkansas	(11-5-82)	MSS-A	
6)	North East Arkansas	(12-7-82)	TM-A	(Duplicate)
7)	Washington, DC	(12-13-82)	MSS-A MSS-P	
8)	North East Arkansas	(1-21-83)	TM-P	
9)	Washington, DC	(1-21-83)	TM-A	